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November 18, 2009

Mr. Pierre M. Saverot – Project Manager
Office of Nuclear Material Safety and Safeguards
Mail Stop: EBB-3D-02M
United States Nuclear Regulatory Commission
Executive Boulevard Building
6003 Executive Boulevard
Rockville, Maryland 20852

RE: Application for Certificate of Compliance No. 9342 for the Model No. Versa-Pac Package, Docket No. 71-9342 – Response to Tele-Conference Criticality Questions

Dear Mr. Saverot,

Century Industries is pleased to have this opportunity to provide the additional information requested during our tele-conference on Tuesday the 10th for your review.

1) Check Table 6-5 regarding cases modeled as a function of poly-moderation and interspersed moderation to identify/confirm the correct modeled drum fill percent.

The initial cases summarized in Table 6-5 represent a single package as a function of the fissile material fill volume. The indicated drum fill percentage corresponds with the input case description. Case VERSAPAK_HAC_SIN_5_A corresponds to a single package with a 5% fill volume and is consistently described.

The second set of cases considers variations in the poly-moderation density. The case designated as "A" corresponds to poly-moderation at 100% of its volume fraction. Cases B through F correspond to reductions in the poly-moderation from 90% to 50%. The drum fill percentage is correctly indicated at 20% fill volume. These cases are correctly described.

The third set of cases considers variations in the interstitial moderation. Case VERSAPAK_HAC_SIN_20_Aa corresponds to a package modeled with a 20% fill volume also with 100% poly-moderation ("A"), but with reduced interstitial moderation ("a" corresponds to a volume fraction of 0.001). The indicted drum fill percentage of 100% is not correct. This case as well as other modeled cases should be indicated as 20% fill volume. This change has been made to Table 6-5.

The forth series of cases modeled the lumped fissile material as discrete spheres with 100% poly-moderation. As indicated in a Response to Question 2, the description of the sphere in terms of its diameter and modeled dimension (inches) are not correct. The sphere radius is actually modeled in centimeters (cm). Also, the table header from the previous page may be further confusing as this header suggests the modeled parameter corresponds to the drum fill percentage. To eliminate this confusion, the table header was changed on the second page of the table to consistently represent the modeled parameter as the lump radius in centimeters (cm). Case VERSAPAK_HAC_SIN_12S_A

The final calculation uses the second homogeneous model (H2) with a reduced containment radius and is further designated with "M". This case is correctly represented and described in Table 6-6.

To further illustrate the differences in the input cases, the following three different described cases, represented in Table 6-6, consider packages with a 10% fill volume however, the drum arrangements are different. Case VERSAPAK_HAC_INFH_10_A models the fissile mass within the base of the package with package arrangement in an infinite hex-lattice array. Case VERSAPAK_HAC_INFH2_10_A models the fissile mass within the base of the package with the bottom package inverted and the top package in its normal orientation with package arrangement in an infinite hex-lattice array. Case VERSAPAK_HAC_INFS2_10_A uses the inverted model with packages in an infinite square-lattice array. Although there is some similarity in the Case IDs, each represents a unique series of calculations.

With the exception of the noted comment for the fifth series of calculations, the cases presented in Table 6-6 appear to be correctly represented and described.

4) Table 6-3, what is meant by the use of the word void in the modeled material/notes for the payload vessel inner diameter.

The fissile material is initially modeled in a defined volume with the remaining interstitial volume completely filled with poly-moderation. In this case, the sum of the volume fractions of both fissile material and poly-moderation are equal to unity. Subsequent calculations reduce the poly-moderation volume fraction to demonstrate that the system is not over moderated (or not more reactive with partial poly-moderation). In the latter case, the mixture is then comprised of fissile material, poly-moderation, and void. Void is technically modeled within the mixture under conditions in which the summed fissile material and poly-moderation volume fractions are less than unity.

These clarifying remarks were added to Table 6-3.

5) Input Cases use of multiple water regions - basis or reasoning with use.

The input cases initially modeled water moderator variations within the package, between packages, and also as full density water reflection. The three mixtures were modeled to correspond to the three different package and boundary regions. The input cases can be further simplified with the use of two water mixtures to represent interstitial and full water reflection.

If you need any additional information, please let me know.

Best regards,

William M. Arnold

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Attachments: Table 6-3 , 6-5 & 6-6

Cc: File

Table 6-3 Century Versa-Pac Shipping Container Dimensions and Materials

Component	Actual Dimension (in)	Actual Dimension (cm)	Modeled Dimension (in)	Modeled Dimension (cm)	Actual Material	Modeled Material/Notes
Radial Direction						
Payload vessel Inner diameter	15.0	38.1	15.0 – 15.125	38.1 – 38.4175	Payload – Containment Boundary	The fissile material is initially modeled in a defined volume with the remaining interstitial volume completely filled with poly-moderation. In this case, the sum of the volume fractions of both fissile material and poly-moderation are equal to unity. Subsequent calculations reduce the poly-moderation volume fraction to demonstrate that the system is not over moderated (or not more reactive with partial poly-moderation). In the latter case, the mixture is then comprised of fissile material, poly-moderation, and void. Void is technically modeled within the mixture under conditions in which the summed fissile material and poly-moderation volume fractions are less than unity. Both homogeneous and in-homogeneous (lumped) fissile masses are modeled.
Payload vessel Wall thickness	0.1345 (10 ga)	0.3416	0.1211	0.3076	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Insulation thickness	3.0	7.62	2.5	6.35	Insulation	Optimum interspersed moderator
Inner liner wall thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Outer insulation, vertical and horizonal tubing and angles	1.25	3.175	1.25 NCT 0.25 HAC	3.175 NCT 0.6356 HAC	Carbon Steel & Insulation	Optimum interspersed moderator. Carbon steel tubing and angles are neglected for conservatism.
Outer liner wall thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Drum wall thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Drum outer radius	11.531 [Note 1]	29.2887	11.250 NCT [Note 2] 10.593 HAC	28.575 NCT 26.908 HAC	N/A	The outer radius of the 55 gallon package is 23". Neglicting the drum stiffeners and bolt ring reduces the outer diameter to 22-1/2". For the bounding HAC/NCT model, the 55-gallon drum is further modeled with a reduced outer diameter of 1.313" which significantly bounds the maximum reduced dimension resulting from the tests of 0.313" (5/16") as indicated in Section 2. The outer radius of the 55 gallon package HAC model is then 21.1875".
Axial Direction From Bottom of Package						
Drum bottom thickness	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Bottom reinforcing plate	0.25	0.635	0.24	0.6096	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance

Bottom insulation layer thickness	2.5	6.35	2.5	6.35	Insulation	Optimum interspersed moderator
Payload vessel Bottom wall thickness	0.1345 (10 ga)	0.3416	0.1211	0.3076	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Payload vessel Inner height	27.0625	38.1	27.0625 – 27.1875	38.1 – 38.4175	Payload – Containment Boundary	0.350 kg U-235 payload with varying poly-moderation using void to create all densities that physically fit in the cylinder for the maximum mass allowed. Both homogeneous and in-homogeneous (lumped) fissile masses are modeled.
Payload vessel Closure lid wall thickness	0.50	1.27	0.49	1.2446	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Lid-to-plug gap	0.9065	2.3025	0.4265	1.0833	Gasket, Carbon steel bolts, Air	Clearance for gasket and inner fasteners. Modeled as optimum interspersed moderator
Inner plug liner	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Top insulation layer thickness	2.5	6.35	2.5	6.35	Insulation	Optimum interspersed moderator
Drum lid	0.0598 (16 ga)	0.1518	0.0533	0.1354	Carbon steel	Carbon steel modeled with reduced manufacturing tolerance
Drum outer height	34.5 [Note 3]	87.63	34.0 NCT [Note 4] 33.625 HAC	86.36 NCT 85.4075 HAC	N/A	The outer height of the 55 gallon package is 34-1/2". Neglicting the drum bottom chime reduces the outer height to 34". For the bounding HAC model, the 55-gallon drum is modeled with a reduced outer height of 0.875" which bounds the maximum reduced dimension resulting from the tests of 0.250" (1/4") as indicated in Section 2. The outer height of the 55 gallon package HAC model is then 33.625".

Notes on Table 6-3:

1. Dimension includes the drum ring stiffeners, lid, chime, and lock ring.
2. Dimension does not include the drum ring stiffeners, lid, chime, or lock ring.
3. Dimension includes the drum bottom chime.
4. Dimension does not include the drum bottom chime.

Table 6-5 Summary of Single Package Results

Case ID	Drum Fill Percent	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Homogeneous Fissile Material as a Function of Drum Fill Percentage										
VERSAPAK_HAC_SIN_5_A	5	100	0.350	0.0001	Yes	0.1546	0.0006	0.1558	4.87E-02	
VERSAPAK_HAC_SIN_10_A	10	100	0.350	0.0001	Yes	0.3155	0.0007	0.3169	3.45E-02	
VERSAPAK_HAC_SIN_15_A	15	100	0.350	0.0001	Yes	0.3950	0.0006	0.3962	3.11E-02	
VERSAPAK_HAC_SIN_20_A[Note 1]	20	100	0.350	0.0001	Yes	0.4193	0.0006	0.4205	2.97E-02	
VERSAPAK_HAC_SIN_30_A	30	100	0.350	0.0001	Yes	0.3993	0.0007	0.4007	2.84E-02	
VERSAPAK_HAC_SIN_40_A	40	100	0.350	0.0001	Yes	0.3591	0.0005	0.3601	2.79E-02	
VERSAPAK_HAC_SIN_60_A	60	100	0.350	0.0001	Yes	0.2849	0.0003	0.2855	2.74E-02	
VERSAPAK_HAC_SIN_80_A	80	100	0.350	0.0001	Yes	0.2318	0.0002	0.2322	2.71E-02	
VERSAPAK_HAC_SIN_100_A	100	100	0.350	0.0001	Yes	0.1946	0.0002	0.1950	2.70E-02	
Homogeneous Fissile Material as a Function of Poly-Moderation Density										
VERSAPAK_HAC_SIN_20_A[Note 1]	20	100	0.350	0.0001	Yes	0.4193	0.0006	0.4205	2.97E-02	**k_{eff} decreases with reduced poly-moderation density**
VERSAPAK_HAC_SIN_20_B	20	90	0.350	0.0001	Yes	0.4003	0.0007	0.4017	3.02E-02	
VERSAPAK_HAC_SIN_20_C	20	80	0.350	0.0001	Yes	0.3741	0.0007	0.3755	3.09E-02	
VERSAPAK_HAC_SIN_20_D	20	70	0.350	0.0001	Yes	0.3385	0.0006	0.3397	3.19E-02	
VERSAPAK_HAC_SIN_20_E	20	60	0.350	0.0001	Yes	0.2936	0.0006	0.2948	3.33E-02	
VERSAPAK_HAC_SIN_20_F	20	50	0.350	0.0001	Yes	0.2397	0.0006	0.2409	3.54E-02	
Homogeneous Fissile Material as a Function of Interspersed-Moderator Density										
VERSAPAK_HAC_SIN_20_A[Note 1]	20	100	0.350	0.0001	Yes	0.4193	0.0006	0.4205	2.97E-02	**k_{eff} increases with increased interspersed moderation density**
VERSAPAK_HAC_SIN_20_Aa	20	100	0.350	0.001	Yes	0.4195	0.0006	0.4207	2.97E-02	
VERSAPAK_HAC_SIN_20_Ab	20	100	0.350	0.01	Yes	0.4215	0.0006	0.4227	2.96E-02	
VERSAPAK_HAC_SIN_20_Ac	20	100	0.350	0.1	Yes	0.4335	0.0006	0.4347	2.95E-02	
VERSAPAK_HAC_SIN_20_Ad	20	100	0.350	0.5	Yes	0.4708	0.0007	0.4722	2.91E-02	
VERSAPAK_HAC_SIN_20_Ae	20	100	0.350	1.0	Yes	0.4839	0.0006	0.4851	2.90E-02	**Maximum Homogeneous Result**

Case ID	Sphere Radius, cm	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Single Lumped Fissile Mass										
VERSAPAK_HAC_SIN_6S_A	6	100	0.350	0.0001	Yes	0.6471	0.0012	0.6495	1.45E-01	
VERSAPAK_HAC_SIN_8S_A	8	100	0.350	0.0001	Yes	0.7927	0.0012	0.7951	6.55E-02	
VERSAPAK_HAC_SIN_10S_A	10	100	0.350	0.0001	Yes	0.8683	0.0012	0.8707	4.47E-02	
VERSAPAK_HAC_SIN_12S_A Note 2	12	100	0.350	0.0001	Yes	0.8814	0.0012	0.8838	3.66E-02	**Maximum Lumped Result**
VERSAPAK_HAC_SIN_14S_A	14	100	0.350	0.0001	Yes	0.8429	0.0011	0.8451	3.27E-02	
Single Lumped Fissile Mass as a Function of Poly-Moderation Density										
VERSAPAK_HAC_SIN_12S_A Note 2	12	100	0.350	0.0001	Yes	0.8814	0.0012	0.8838	3.66E-02	**k_{eff} decreases with reduced poly-moderation density**
VERSAPAK_HAC_SIN_12S_B	12	90	0.350	0.0001	Yes	0.8431	0.0012	0.8455	3.77E-02	
VERSAPAK_HAC_SIN_12S_C	12	80	0.350	0.0001	Yes	0.7952	0.0011	0.7974	3.90E-02	
VERSAPAK_HAC_SIN_12S_D	12	70	0.350	0.0001	Yes	0.7411	0.0011	0.7433	4.07E-02	
VERSAPAK_HAC_SIN_12S_E	12	60	0.350	0.0001	Yes	0.6800	0.0012	0.6824	4.27E-02	

Notes on Table 6-5:

1. Duplicate entry for observance of trend.
2. Duplicate entry for observance of trend.

Table 6-6 Summary of Hypothetical Accident Condition Package Results for Homogeneous Models

Case ID	Drum Fill Percent	Poly-Moderation	^{235}U Mass (kg)	Interspersed Moderation (water volume fraction)	Close Water Reflection	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF (eV)	Comments
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Package Model										
VERSAPAK_HAC_INFH_5_A	5	100	0.350	0.0001	Yes	0.6807	0.0008	0.6823	4.77E-02	
VERSAPAK_HAC_INFH_10_A [Note 1]	10	100	0.350	0.0001	Yes	0.7158	0.0006	0.7170	3.46E-02	
VERSAPAK_HAC_INFH_15_A	15	100	0.350	0.0001	Yes	0.6673	0.0005	0.6683	3.14E-02	
VERSAPAK_HAC_INFH_20_A	20	100	0.350	0.0001	Yes	0.6104	0.0005	0.6114	3.00E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Poly-Moderation Density – Bottom Filled Package Model										
VERSAPAK_HAC_INFH_10_A [Note 1]	10	100	0.350	0.0001	Yes	0.7158	0.0006	0.7170	3.46E-02	**k_{eff} decreases with reduced poly-moderation density**
VERSAPAK_HAC_INFH_10_B	10	90	0.350	0.0001	Yes	0.7149	0.0006	0.7161	3.58E-02	
VERSAPAK_HAC_INFH_10_C	10	80	0.350	0.0001	Yes	0.7082	0.0006	0.7094	3.76E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Interspersed Moderator Density – Bottom Filled Package Model										
VERSAPAK_HAC_INFH_10_Aa	10	100	0.350	0.001	Yes	0.7083	0.0006	0.7095	3.45E-02	**k_{eff} decreases with increased interspersed moderator density**
VERSAPAK_HAC_INFH_10_Ba	10	90	0.350	0.001	Yes	0.7063	0.0006	0.7075	3.58E-02	
VERSAPAK_HAC_INFH_10_Ca	10	80	0.350	0.001	Yes	0.7002	0.0007	0.7016	3.75E-02	
VERSAPAK_HAC_INFH_10_Ab	10	100	0.350	0.01	Yes	0.6420	0.0006	0.6432	3.42E-02	
VERSAPAK_HAC_INFH_10_Bb	10	90	0.350	0.01	Yes	0.6347	0.0006	0.6359	3.54E-02	
VERSAPAK_HAC_INFH_10_Cb	10	80	0.350	0.01	Yes	0.6209	0.0007	0.6223	3.70E-02	
VERSAPAK_HAC_INFH_10_Ac	10	100	0.350	0.1	Yes	0.4959	0.0007	0.4973	3.30E-02	
VERSAPAK_HAC_INFH_10_Bc	10	90	0.350	0.1	Yes	0.4780	0.0007	0.4794	3.39E-02	
VERSAPAK_HAC_INFH_10_Cc	10	80	0.350	0.1	Yes	0.4551	0.0007	0.4565	3.49E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Inverted Bottom Package Model										
VERSAPAK_HAC_INFH2_5_A	5	100	0.350	0.0001	Yes	0.6817	0.0007	0.6831	4.77E-02	**Bottom filled inverted model (H2) is more reactive than previous bottom filled (H) model**
VERSAPAK_HAC_INFH2_5_B	5	90	0.350	0.0001	Yes	0.6625	0.0006	0.6637	5.15E-02	
VERSAPAK_HAC_INFH2_5_C	5	80	0.350	0.0001	Yes	0.6374	0.0006	0.6386	5.70E-02	
VERSAPAK_HAC_INFH2_5_D	5	70	0.350	0.0001	Yes	0.608	0.0007	0.6094	6.50E-02	
VERSAPAK_HAC_INFH2_5_E	5	60	0.350	0.0001	Yes	0.5727	0.0006	0.5739	7.74E-02	
VERSAPAK_HAC_INFH2_5_F	5	50	0.350	0.0001	Yes	0.5317	0.0006	0.5329	9.90E-02	
VERSAPAK_HAC_INFH2_10_A	10	100	0.350	0.0001	Yes	0.7161	0.0007	0.7175	3.46E-02	

VERSAPAK_HAC_INFH2_10_B	10	90	0.350	0.0001	Yes	0.7141	0.0006	0.7153	3.58E-02	**k_{eff} decreases with reduced poly-moderation density**
VERSAPAK_HAC_INFH2_10_C	10	80	0.350	0.0001	Yes	0.7082	0.0006	0.7094	3.76E-02	
VERSAPAK_HAC_INFH2_10_D	10	70	0.350	0.0001	Yes	0.697	0.0007	0.6984	3.99E-02	
VERSAPAK_HAC_INFH2_10_E	10	60	0.350	0.0001	Yes	0.6769	0.0007	0.6783	4.34E-02	
VERSAPAK_HAC_INFH2_10_F	10	50	0.350	0.0001	Yes	0.6465	0.0007	0.6479	4.91E-02	
VERSAPAK_HAC_INFH2_15_A	15	100	0.350	0.0001	Yes	0.6664	0.0006	0.6676	3.15E-02	
VERSAPAK_HAC_INFH2_15_B	15	90	0.350	0.0001	Yes	0.6773	0.0005	0.6783	3.22E-02	
VERSAPAK_HAC_INFH2_15_C	15	80	0.350	0.0001	Yes	0.6829	0.0006	0.6841	3.32E-02	
VERSAPAK_HAC_INFH2_15_D	15	70	0.350	0.0001	Yes	0.6874	0.0006	0.6886	3.45E-02	
VERSAPAK_HAC_INFH2_15_E	15	60	0.350	0.0001	Yes	0.6824	0.0006	0.6836	3.65E-02	
VERSAPAK_HAC_INFH2_15_F	15	50	0.350	0.0001	Yes	0.6707	0.0006	0.6719	3.94E-02	
VERSAPAK_HAC_INFH2_20_A	20	100	0.350	0.0001	Yes	0.6089	0.0005	0.6099	3.00E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Poly-Moderation Density – Bottom Filled Inverted Bottom Package Model										
VERSAPAK_HAC_INFH2_10_Aa	10	100	0.350	0.001	Yes	0.7090	0.0006	0.7102	3.45E-02	**k_{eff} decreases with reduced poly-moderation density and with increased interspersed moderator density**
VERSAPAK_HAC_INFH2_10_Ba	10	90	0.350	0.001	Yes	0.7060	0.0006	0.7072	3.58E-02	
VERSAPAK_HAC_INFH2_10_Ca	10	80	0.350	0.001	Yes	0.6990	0.0006	0.7002	3.75E-02	
VERSAPAK_HAC_INFH2_10_Ab	10	100	0.350	0.01	Yes	0.6431	0.0007	0.6445	3.42E-02	
VERSAPAK_HAC_INFH2_10_Bb	10	90	0.350	0.01	Yes	0.6325	0.0007	0.6339	3.54E-02	
VERSAPAK_HAC_INFH2_10_Cb	10	80	0.350	0.01	Yes	0.6197	0.0007	0.6211	3.70E-02	
VERSAPAK_HAC_INFH2_10_Ac	10	100	0.350	0.1	Yes	0.4956	0.0008	0.4972	3.30E-02	
VERSAPAK_HAC_INFH2_10_Bc	10	90	0.350	0.1	Yes	0.4762	0.0007	0.4776	3.39E-02	
VERSAPAK_HAC_INFH2_10_Cc	10	80	0.350	0.1	Yes	0.4530	0.0007	0.4544	3.50E-02	
Infinite Square Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Inverted Bottom Package Model										
VERSAPAK_HAC_INFS2_5_A	5	100	0.350	0.0001	Yes	0.6800	0.0007	0.6814	4.77E-02	**k_{eff} decreases for square array**
VERSAPAK_HAC_INFS2_10_A	10	100	0.350	0.0001	Yes	0.7145	0.0007	0.7159	3.46E-02	
VERSAPAK_HAC_INFS2_15_A	15	100	0.350	0.0001	Yes	0.6663	0.0005	0.6673	3.14E-02	
VERSAPAK_HAC_INFS2_20_A	20	100	0.350	0.0001	Yes	0.6082	0.0005	0.6092	3.01E-02	
VERSAPAK_HAC_INFS2_30_A	30	100	0.350	0.0001	Yes	0.5063	0.0004	0.5071	2.88E-02	
Infinite Triangular Package Array - Homogeneous Fissile Material as a Function of Drum Fill Percentage – Bottom Filled Inverted Bottom Package Model – Reduced Containment Cavity Radius										
VERSAPAK_HAC_INFH2_10M_A	10	100	0.350	0.0001	Yes	0.7292	0.0006	0.7304	3.46E-02	**Containment radius reduced from 19.2088 to 19.05-cm**

Notes on Table 6-6:

1. Duplicate entry for observance of trend.